RECENT PROGRESS IN DOUBLE STAR ASTRONOMY: A REVIEW

By ROBERT G. AITKEN

The field of double star astronomy has been cultivated assiduously by several generations of able astronomers, but it is apparently as fertile as ever and still yields abundant fruit, of new as well as of old and well tried varieties. As evidence for this statement, there are on my desk as I write these lines three recent volumes each containing some thousands of carefully made measures of double stars; several papers on orbits and orbit computations; a paper on the masses of visual binary stars; one on the mean period of binary systems near our Sun; one on the origin of binary stars. I might also cite some of the many programs of observation and discussion that to my certain knowledge are being carried out at present by astronomers in many parts of the world.

No effort will be made in the present paper, to pass all recent work under review. It will be sufficient to describe briefly the books and papers referred to in my second sentence; for they will give a fair idea of the kind of work that is being done. It should, however, be added that photographic measures of double stars and measures with the interferometer have come to the fore as important complements to the ordinary micrometric measures and promise to be of increasing importance in future work.

Professor Comstock's book,[1] the first of three volumes of measures to be noted, completes the record of a program of observing taken up in 1892, the earlier results being published in Parts 1 and 3 of Volume X of the *Publications of the Washburn Observatory*. In his introduction to the present publication he writes, "It was contemplated at the beginning of the series that it should be as nearly as possible homogeneous in character throughout the entire extent and the plan then formed has been adhered to with very little modification." The consequence is that for star after star we have, in Comstock's three

[1]Observations of Double Stars, 1907-1919. *Publ. of the Washburn Observatory of the University of Wisconsin;* Vol. X, Part 4.

volumes, sets of measures made each year or nearly each year from 1892 to 1919 (sometimes from 1888) by the same observer with the same telescope, under as nearly the same conditions as was possible. Such results are of greater value in the investigations of the motions of these systems than ten times as many measures made less systematically. This is particularly true of systems (70 *Ophiuchi* is a good example) in which we have reason to suspect the existence of an unseen star which affects the observed motion of the two visible components. Long series of measures, such as Comstock's, by several different observers, would permit the determination of the personal (systematic) error of the observer, which is absolutely required in the discussion of the motion in these systems. Professor Comstock has made a careful investigation of the errors of his measures and from his summary it appears not only that the probable error of measure has been remarkably constant throughout the quarter century covered by his program, but that his work ranks in accuracy with that of the best observers from Struve down to the present day. The systematic error is not discussed in the present paper, but ample data are given for its determination when comparable series of measures by other observers are available.

Professor Comstock has utilized his measures, with those by other observers, in the investigation of the orbits of a number of binary systems. In connection with this work he has made important contributions, especially in the last two or three years, to orbit theory, giving particular attention to methods applicable to systems for which the data are insufficient to permit satisfactory use of the usual methods.

The next volume[2] is in some respects of a different character. It is well known that the observation of double stars has been the main feature of the observing program carried out with the 28-inch refractor at the Royal Observatory, Greenwich, since the erection of the telescope in 1893. The telescope was in charge of Mr. Thomas Lewis until 1917, and he was responsible for the observing program. He was at first the only observer,

[2]Catalogue of Double Stars from Observations made at the Royal Observatory, Greenwich, with the 28-inch refractor during the years 1893-1919, under the direction of Sir Frank Watson Dyson, LL.D., F.R.S., Astronomer Royal.

and continued to be the principal observer until 1911, but, in 1895 he was joined by Mr. Bowyer, in 1897 by Mr. Bryant and in 1902 by Mr. Furner. Other members of the staff also made smaller numbers of measures. During the war, when other duties interfered with the work by the regular observers, a large number of measures was made by M. Robert Jonckheere, director of the observatory of the University of Lille. In August, 1919, the telescope was dismounted for repairs, and work on double stars has but recently been resumed, under the direction of Mr. John Jackson.

Before 1910 the detailed measures made each year were published in the annual Greenwich volumes. This practice was then discontinued but the mean results were published in the *Monthly Notices R. A. S.*, as before. The first part of the volume now before us consists therefore of the separate observations for the years 1910-1919, except those made by M. Jonckheere, which have, for the most part, been published in his *Catalogue and Measures of Double Stars*[3] and in papers in the *Astronomical Journal.*

The chief part of the volume is a general catalogue of all the measures from 1893 to August, 1919 (except M. Jonckheere's), in which not the separate measures, but the mean results are given. The preparation of this catalogue was begun before the war, the measures to 1914 being collected by Mr. Lewis. It has now been completed by Messrs. Jackson and Furner. Here we are concerned with measures by a number of different observers, and before combining them into mean results, a discussion of personal equation is desirable if not, indeed, essential. This has been carried out fully so far as observed distances are concerned, but not for the position angles. It appears that the three chief observers, Lewis, Bryant and Bowyer, have but slight relative personal equations; but Furner, Eddington and Chapman systematically measured the distances larger. To their measures of distance, therefore, corrections have been applied before they were combined with the others to form the mean results.

The proportion of binaries in rapid motion is smaller in this

[3] *Memoirs, R. A. S.*, Vol. LXI, 1917.

catalogue than in Comstock's because the observing program was at first largely influenced by the desire to bring our knowledge of the motion (or lack of change) of all the Struve stars as nearly as possible up to date. But here again we find long series of measures of many interesting systems, and—a point to be commented upon a little later—many close and difficult pairs. Where the motion is rapid, annual means are given; when little or no change has been observed, the measures over several years have been combined. The data are conveniently arranged, and, for comparison, the earliest known measure of each pair, taken usually from Burham's *General Catalogue,* is given. The appended notes, written by Mr. Jackson ,are a valuable feature of the catalogue, for each note gives real information on the motions, orbital or proper, the parallax and the spectral class.

The discussion of the motion of these stars led Mr. Jackson also to compute orbits for 25 systems. These are given in the final section of the volume. Some of the orbits are, frankly, first approximations merely, the data not being sufficient for anything more, but even these will serve usefully as points of departure in subsequent investigations. Other orbits will be found to be practically definitive.

The very important paper by Jackson and Furner on the Hypothetical Parallaxes of 556 Double Stars, which appeared in the *Monthly Notices R. A. S.,* for November, 1920, will be recalled by all interested in the study of double stars or of stellar distances. The list of these parallaxes, with those of ten additional stars, is appended to the introduction of this volume.

The two volumes just noted both relate to measures made at northern observatories and chiefly of stars north of the celestial equator. The volume[4] to which we now turn, contains measures of southern double stars only, and chiefly measures of pairs south of —30° declination. It is the more welcome on that very account because we are especially in need of double star observers in the southern hemisphere. For many years the only double star work done at stations south of our equator has been that by Innes, at Johannesburg, South Africa, and that by Hussey

[4]La Plata Equatorial Observations, 1918-1921, by Bernhard H. Dawson, *Universidad Nacional de la Plata, Publicationes del Observatorio Astronomico;* Tomo IV (Parte 11a).

and, more recently, Dawson at La Plata. Other demands upon Mr. Innes's time of late have interfered seriously with his double star work and that places even greater responsibility upon La Plata for observations such as those in the present volume. It is to be hoped that Mr. Dawson will be able to continue systematically the work in which he has already made such an excellent record.

Mr. Dawson's program of work included the measurement of all Hershel and all Burnham stars south of —30°; the pairs of Hershel's Cape Catalogue north of that declination not measured since 1906 and of all stars south of 21° 40′ in Burnham's *General Catalogue* not identified elsewhere by 1918. In addition, many other systems were measured, including 111 new pairs, about half the latter resulting from the systematic search for new pairs which was begun in 1920. In all there are about 7500 measures in the volume of which this publication is the second part.

From the nature of this program a large percentage of the measures relate to comparatively wide pairs: but there are also numerous measures of closer pairs, particularly of those discovered at La Plata by Hussey and by Dawson and in South Africa by Innes. Some of these are very close and difficult, and must have required excellent observing conditions. This remark applies also to the many difficult pairs measured at Greenwich and at Madison. Over-enthusiastic praise of the excellent observing conditions ("good seeing") prevailing at certain specially favored stations sometimes leads to the impression that these stations are the only ones at which work demanding such conditions can be done successfully. The truth is that no station has a monopoly in this respect; every station at present occupied by an astronomical observatory has nights suitable for the best work that can be done with the available telescopes; the chief difference is in the number of such nights which may be counted upon in a year.

The three volumes we have been examining contain the direct data of observation, which are the absolute prerequisite to any study of the motions in the binary systems or to any other investigations in which a knowledge of these motions is involved.

Like the measures of the positions of the stars, to which Dr. Schlesinger has recently called attention in his address as retiring president of the American Astronomical Society,[5] they are in a large degree a legacy which the observer of today leaves to his successors, for their full value may not be realized for a century or more. But that does not mean that they cannot, to some extent, be made useful immediately, as the shorter papers I wish to mention here prove.

In the first of these,[6] Professors Miller and Pitman, of the Sproul Observatory, give the results of their determinations of the masses of a number of visual binary stars for which orbits and parallax measures are available. The parallax program of the Sproul Observatory was, in fact, "built around a desire to determine the masses of stars"; and as we can only determine the mass of a star by measuring its effect upon the motion of another star, our knowledge of individual stellar masses is at present entirely limited to binary systems. They find, as others have done, a regular decrease in the average mass value in passing from stars of earlier to those of later spectral class. They call special attention to the desirability of computing the absolute parallaxes of as many binaries as possible. This can be done when we have the elements of the visual orbit, and a measure of the relative radial velocity of the two components, as Rambaut showed in 1886. So far, however, we have such parallaxes for but three systems, δ *Equulei,* α *Centauri,* and ϵ *Hydræ.*[7] They append a table of 18 systems suitable for such determinations, giving the relative radial velocity of each for 1922 and for the date when it will have its maximum value. It is to be hoped that astronomers engaged in radial velocity observations will place some of these stars in their programs.

Professor Hertzsprung[8] is perhaps unnecessarily conservative in his statement that there are only about 50 double stars for which it is at present possible to derive reliable orbits, but the number is certainly regrettably small and he is entirely cor-

[5] "The Positions of the Stars," by Frank Schlesinger, *Pop. Astron.*, **30**, 535, (November) 1922.

[6] "The Masses of Visual Binary Stars," by John A. Miller and John H. Pitman, *A. J.*, **34**, 127, 1922.

[7] Not noted by Miller and Pitman.

[8] "On the Median Period of Binary Systems Near Our Sun," by Ejnar Hertzsprung. *B. A. N.*, **1**, 149, 1922.

rect in saying that we have no knowledge of the median period of the double stars in our catalogues other than that it must be very long. It is possible, however, as he shows, to give a more definite answer with respect to the systems near our Sun, and he finds, in fact ,that the median period of the 21 double stars with a parallax greater than 0″.1 (*i. e.,* within 32.6 light years distance), is 80 years. The orbits of only 13 of these stars are known; for the rest Hertzsprung used estimated periods derived from the apparent radius vector and annual orbital motion, in connection with a study of the corresponding elements in the systems with known orbits.

A number of papers on the orbits or the mass relations of special systems must be passed over in this review, but attention must be directed to a very interesting article by J. H. Jeans on "The Origin of Binary Stars." This problem has been one of those included by Jeans in his masterly discussion of the "Problems of Cosmogony and Stellar Dynamics,"[9] but the treatment there was a strictly mathematical one, and could be followed with pleasure only by the specialist. He has now put his matured views upon this question into language intelligible to the non-mathematical reader in a very interesting article contributed to the January, 1922, number of *Scientia.*

It is very satisfactory to find that his conclusions, based upon the most rigorous mathematical analysis, confirm the opinions reached by many astronomers on the basis of more general considerations that, in respect to their origin and process of evolution, there are at least two classes of binary systems; those which have developed by fission of the parent mass, and those which have developed from two independent nuclei in the primal nebula. In general, the very close pairs belong in the first class; the wider ones in the second. The precise dividing line cannot be fixed, but Jeans gives reasons for the view that most of the spectroscopic binaries with periods of 100 days or less, have originated by fission while the longer period systems represent the survival of independent nuclei. The theory sometimes advanced that binary systems result from the "capture" of one star by another is dismissed as highly improbable. It may be

[9]Adams Prize Essay, *Cambridge Univ. Press,* 1919.

added that on this theory it would be quite impossible to account for such relations between the spectra of the component stars as have been shown to exist by the researches of several astronomers, the most recent and comprehensive investigation being that by Dr. F. C. Leonard, which is now in press as a Lick Observatory Bulletin.

November, 1922.